VACET

Science Impact Highlights

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Ultimately, it's about "understanding"

The purpose of computing is insight, not numbers.

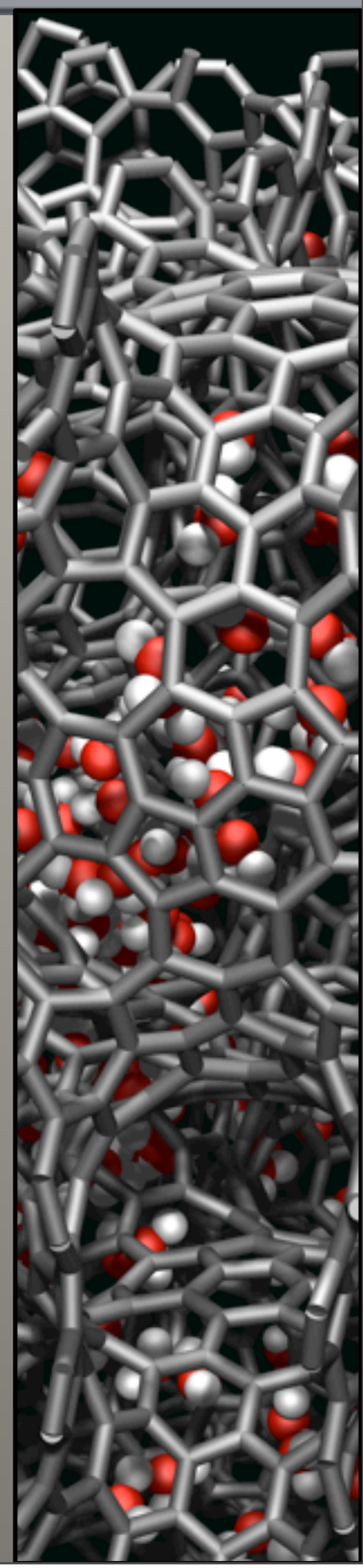
– *Richard Hamming*

The most exciting phrase to hear in science, the one that heralds new discoveries, is not 'Eureka!' (I found it!) but 'That's funny ...'

– *Isaac Asimov*

Large Data Visualization Issues

- Existing, traditional algorithms don't work
  - HPC Challenges (resolution, multivariate, etc.)
  - Human cognition challenges
- We listen to our science stakeholders. They want:
  - To analyze and understand relevant and scientifically interesting data
  - To compute and see relationships between fields
  - Perform these operations on very large data
    - …and on HPC platforms.
  - Want production-quality software, expert help ("fishing instruction")



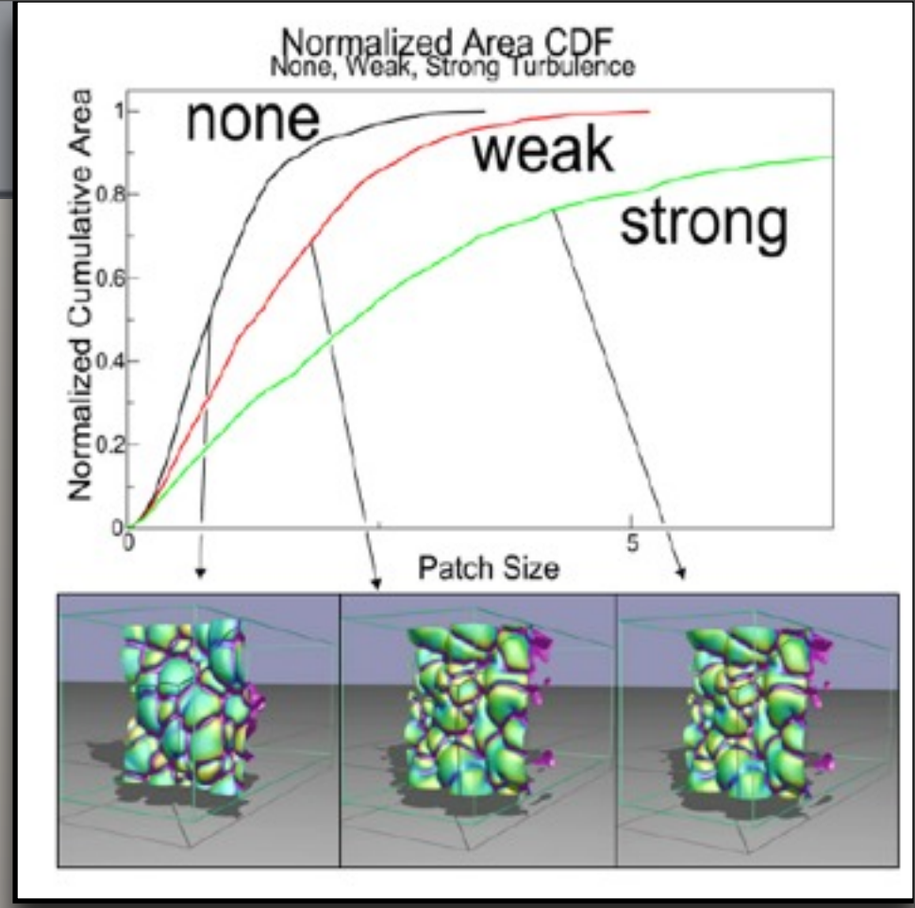
Accomplishments Overview

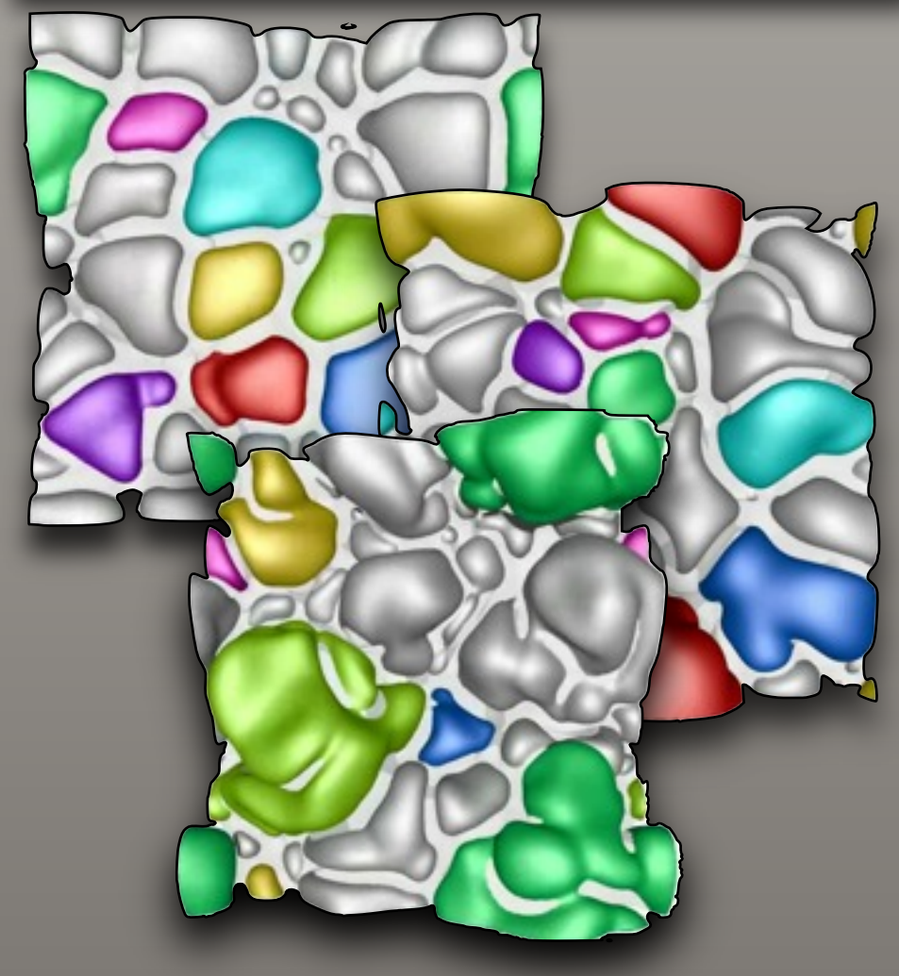
- Made dramatic science understanding impact for multiple science application stakeholders
- Science applications adopt VACET technology as community-wide visual data analysis software infrastructure.
- Stakeholders are voting with their feet.

Specific customer impacts

Combustion, Part 1

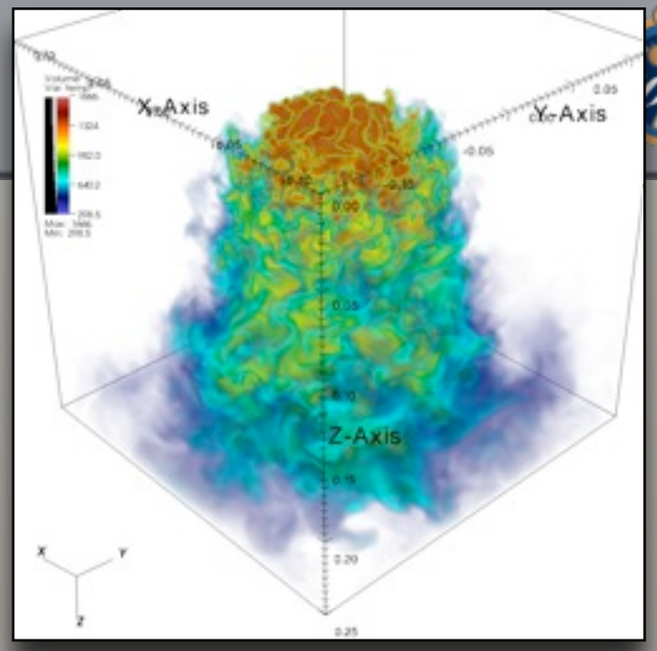
- PI: John Bell (LBNL), SciDAC Community Astrophysics Consortium Partnership, INCITE Awardee.
- Accomplishments:
  - New topological analysis techniques for studying relationship between parameters and their effect.
  - Joint publications with stakeholder.
- Science Impact:
  - First-ever quantitative analysis of large, time-varying combustion simulation data to study influence of turbulence on size/ shape of combustion regions in lean, premixed hydrogen flames.
  - “That’s funny” discovery that stronger turbulence leads to larger cell structures which burn more intensely than expected

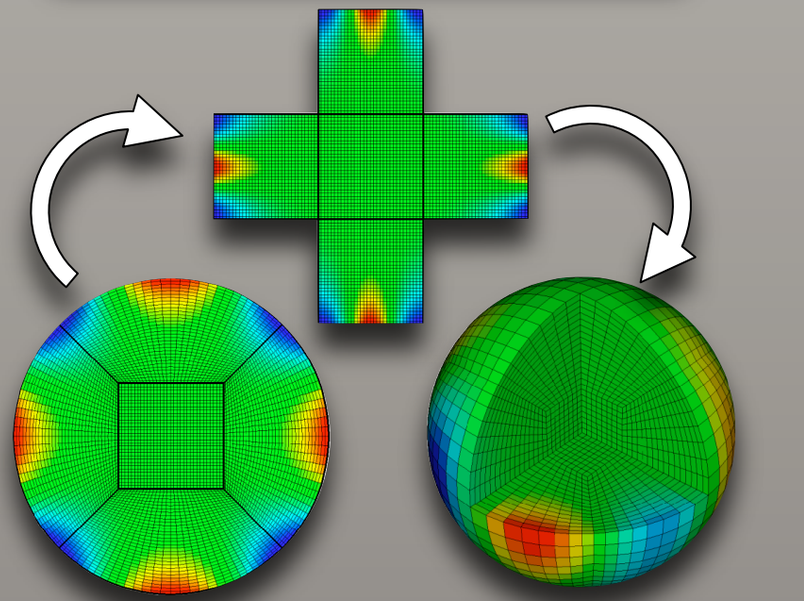


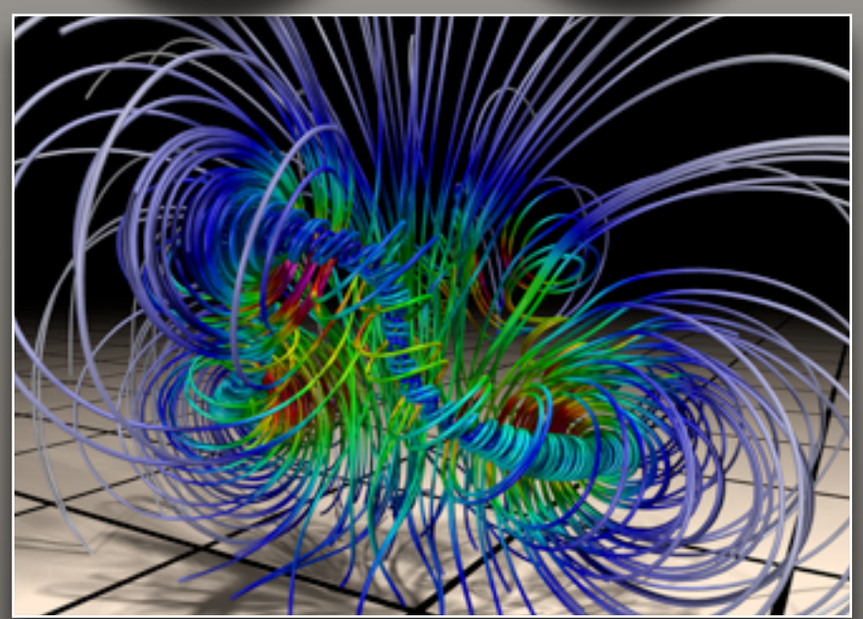


Mathematics

- PI: Phil Colella (LBNL), SciDAC Applied Partial Differential Equations Center
- Accomplishment(s)
  - Software engineering to “bring product to market”. Performance improvements, interface enhancements, file readers, visual data exploration techniques.
- Science Impact
  - Direct cost savings: APDEC no longer uses its own resources (e.g., FTEs) to develop, maintain, and support AMR visualization software.
  - Ability to perform AMR visualization on large, time-varying data, and using parallel platforms.
  - Benefits propagate to all APDEC stakeholders.

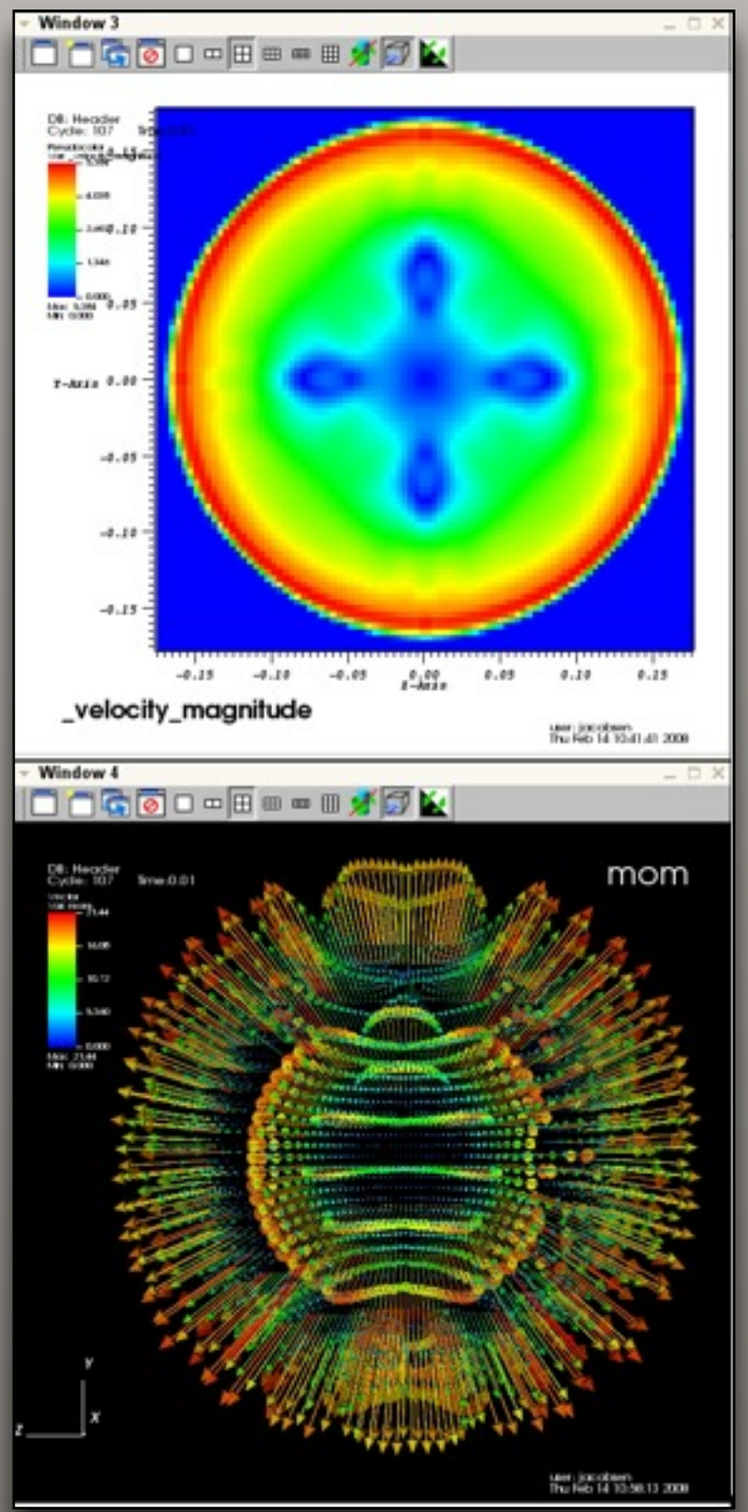






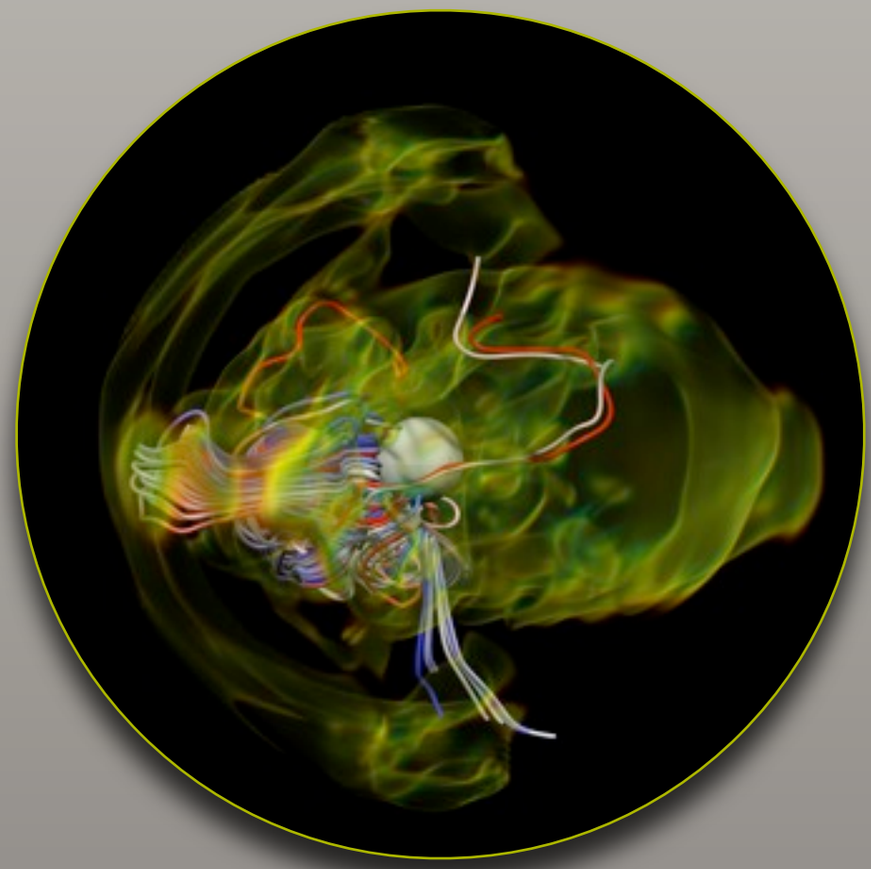
Astrophysics, Part 1

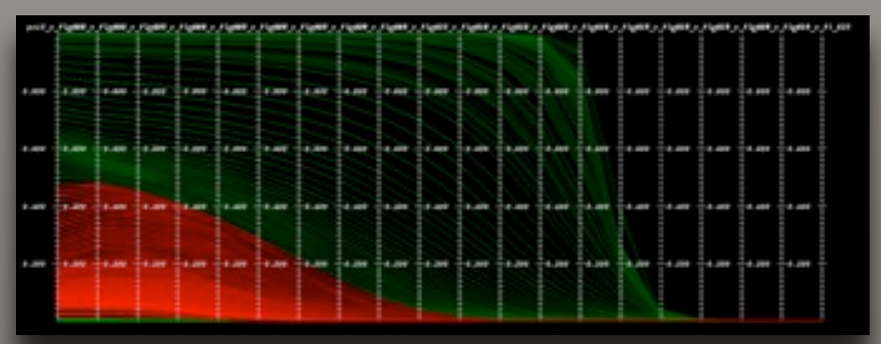
- PI: Stan Woosley (UCSC), John Bell (LBNL), Adam Burrows (Princeton). SciDAC Community Astrophysics Consortium
- Accomplishment
  - Provide production-quality AMR visualization software, including tutorials and support, to CAC code teams.
- Science Impact
  - Reduced complexity, increase in scientific productivity. A single community-wide visual data analysis application, which addresses needs of SN modeling and spectral analysis, helps eliminate the need to learn and use multiple visual data analysis applications.



Astrophysics, Part 2

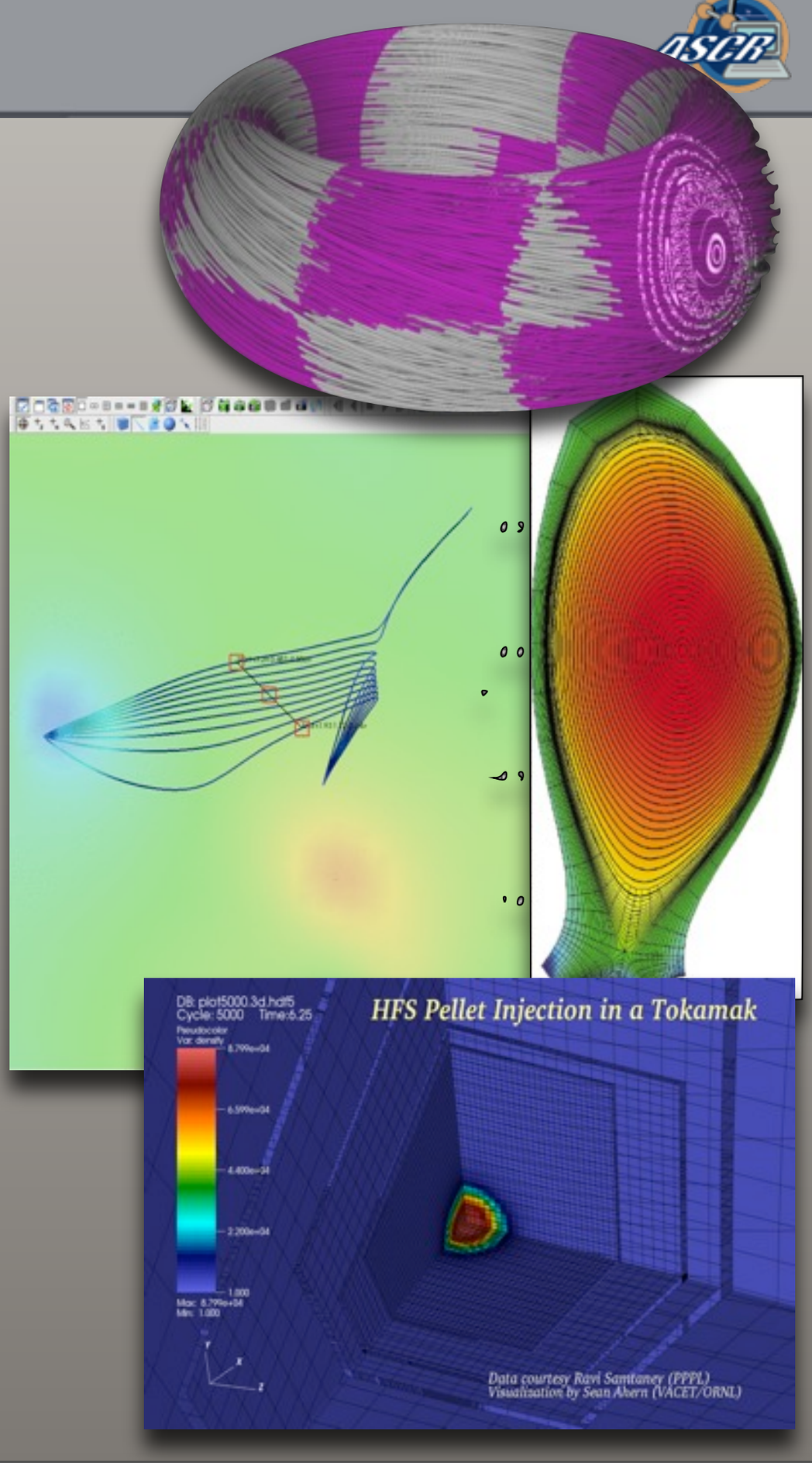
- Pi's/Projects:
  - Tony Mezzacappa (ORNL), INCITE project "Multidimensional Simulations of Core-Collapse Supernovae"
  - Bronson Messer (UT, ORNL), NSF PetaApps project "Supernova Simulations with CHIMERA"
- Accomplishments
  - Provide production-quality custom visualization software, including tutorials and support, to astrophysics code teams.
  - Develop multidimensional visualization and analysis techniques for radiation field exploration
- Science Impact
  - Allowed "first time" visualization of multigroup neutrino radiation field, critical for shockwave development
  - Able to easily explore relationship between simulation parameters (magnetic field and shear)



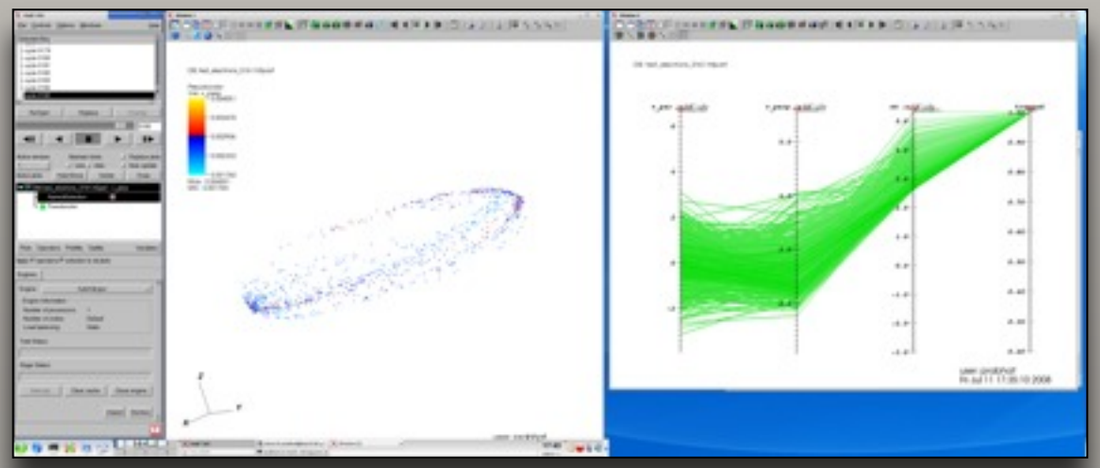


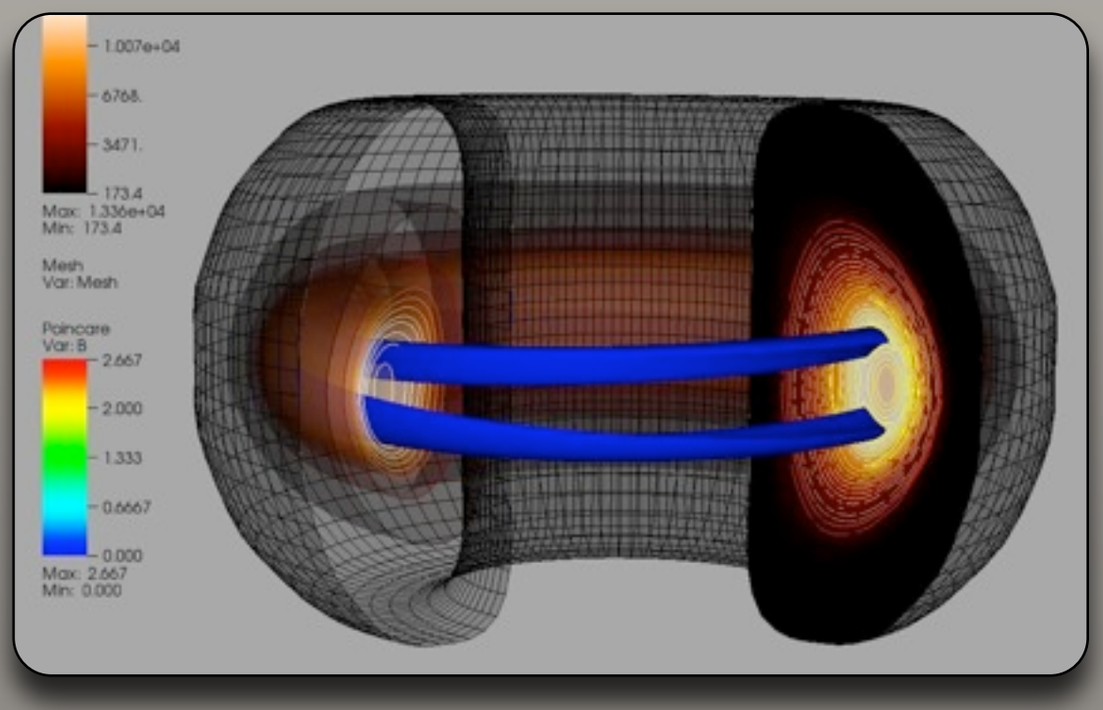
Fusion, Part 1

- PI's/Projects
  - J. Cary (Tech-X), SciDAC Framework Application for Core-Edge Transport Simulations
  - Ravi Samtaney (PPPL), SciDAC Center for Extended Magnetohydrodynamic Modeling
- Accomplishment(s)
  - Leverage VACET investment in (1) AMR visualization software and (2) fundamental visualization software infrastructure, along with (3) one-on-one work with user communities to quickly bring "product to market."
- Science Impact
  - New capability: production quality AMR visualization software infrastructure.
  - Cost savings: community-wide, production-quality visual data analysis software infrastructure helps scientists focus on science rather than visualization software development.



Fusion, Part 2

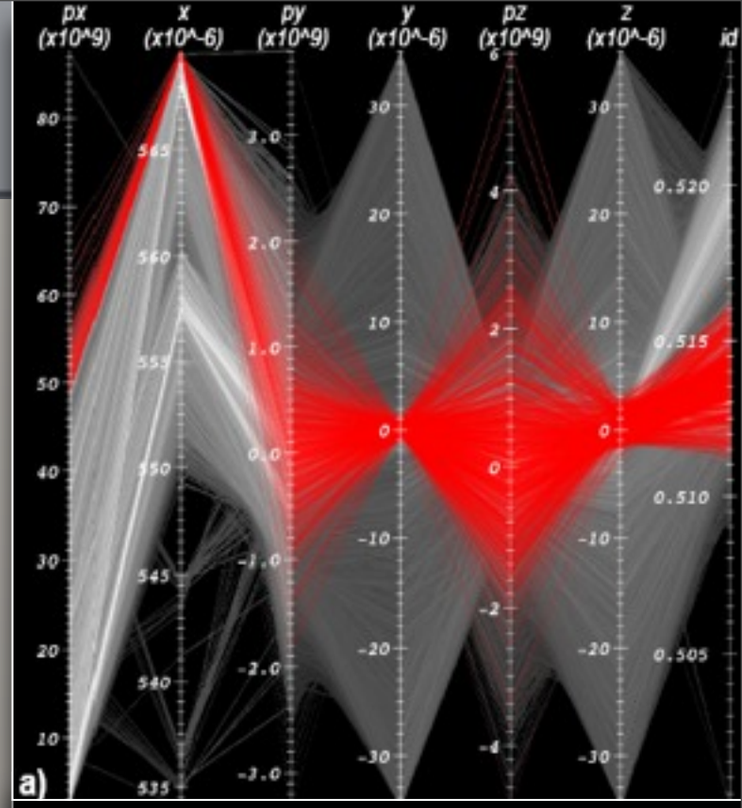


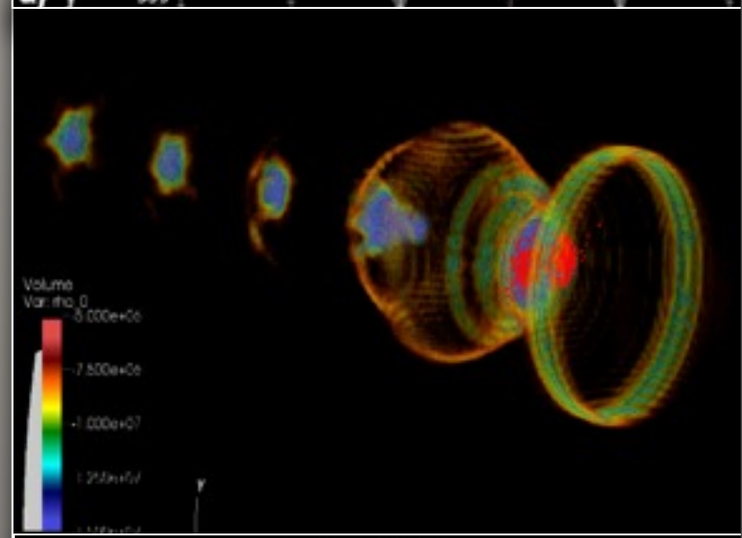


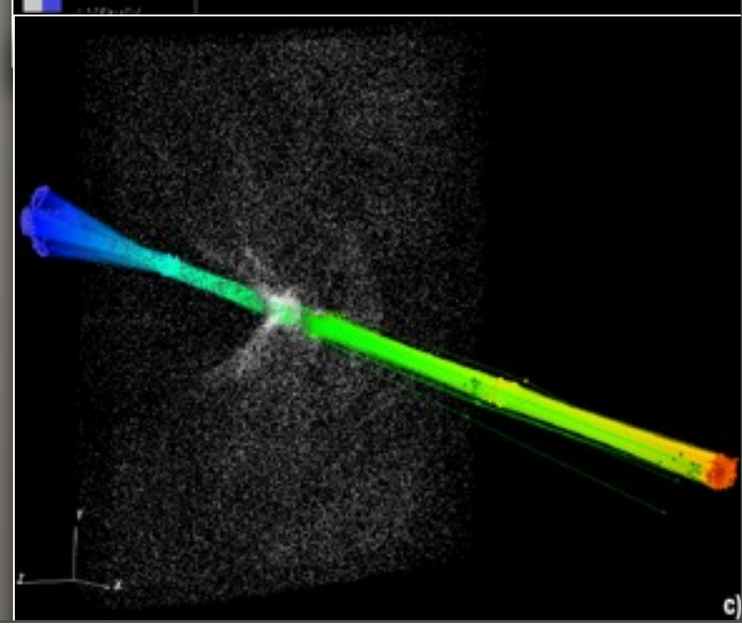
- Fusion Partnership
- PI's:
  - Stephane Ethier (PPPL)
  - Seung-Hoe Ku (NTU), Julian Cummings (CalTech)
  - Scott Kruger (Tech-X), Josh Breslau (PPPL)
  - Bill Nevins (LLNL)
  - Don Batchelor (ORNL), Fred Jaeger (ORNL)
- Objective/Approach
  - These diverse groups have many common needs. Our team is developing/deploying new capabilities to meet these needs in production quality visual data analysis software.
- Impact
  - Enable new science insights in large, complex data.

Accelerator Modeling

- PI: C. Geddes (LBNL), part of SciDAC COMPASS project, INCITE awardee
- Accomplishment:
  - Algorithms and production-quality software infrastructure to perform interactive visual data analysis (identify, track, analyze beam particles) in multi-TB simulation data.
- Science Impact:
  - Replace serial process that took hours with one that takes seconds.
  - New capability: rapid data exploration and analysis.
- Collaborators:
  - SciDAC SDM Center (FastBit)
  - Tech-X (Accelerator scientists)

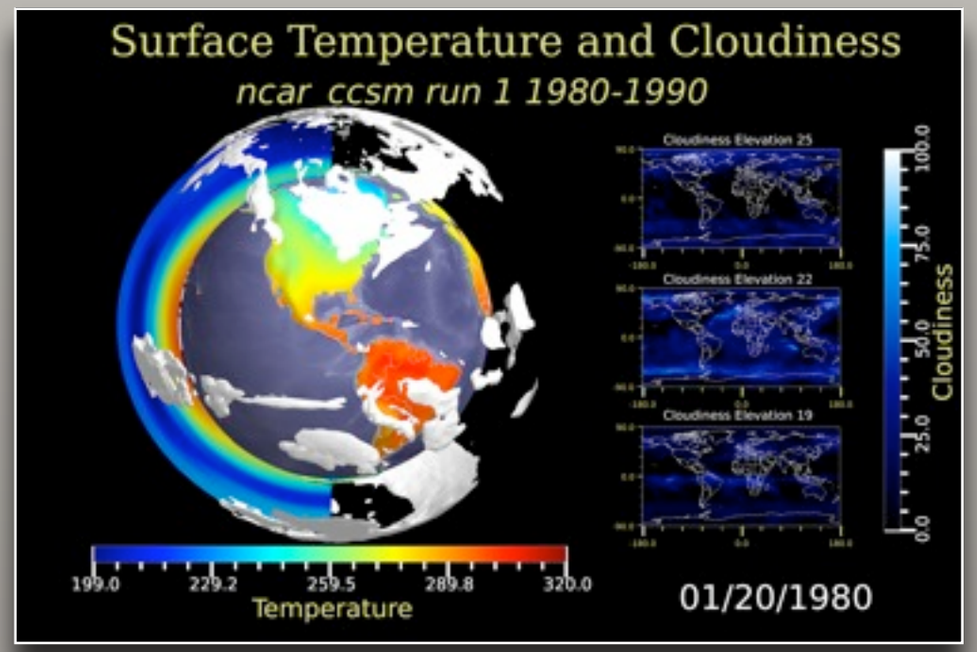


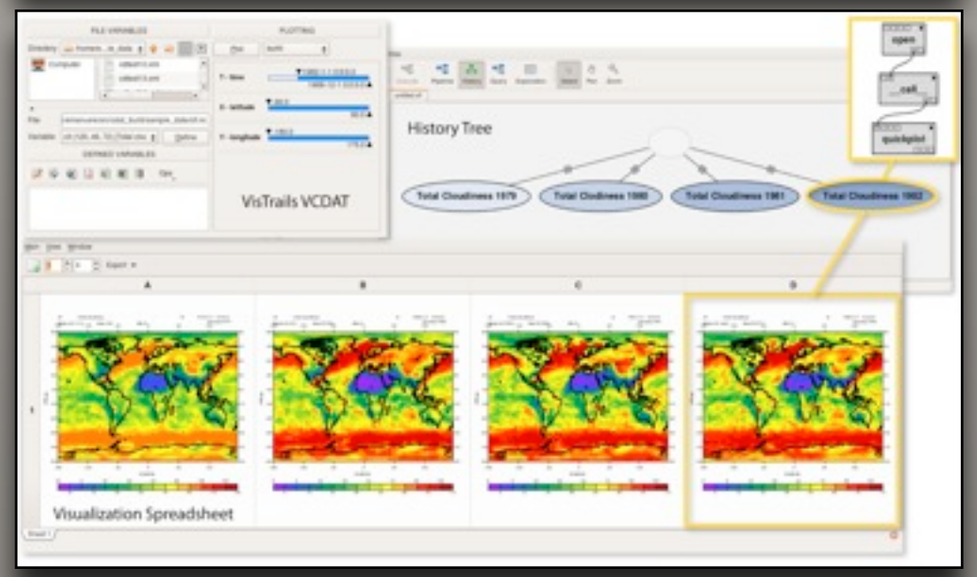




Climate, Part 1

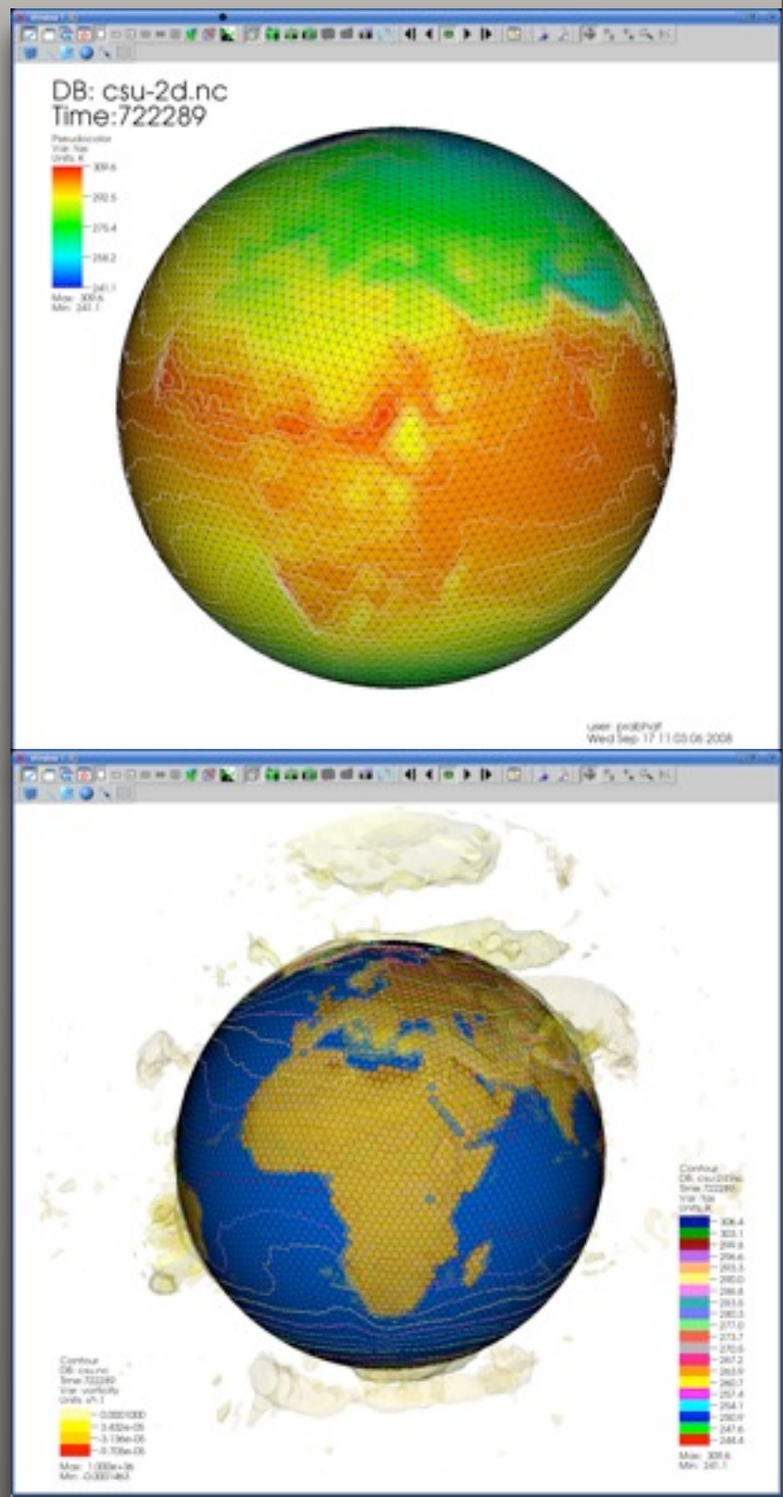
- PI: Dean Williams (LLNL), SciDAC Earth Systems Grid.
  - Other beneficiaries:
    - Community Climate System Model Consortium, Phil Jones (LANL), John Drake (ORNL)
- Accomplishments
  - Software engineering to transition research prototype into production code within a climate community standard visual data analysis system (VCDAT).
  - Automatic provenance tracking of CDAT data analysis sessions
- Science Impacts
  - New capability: 3D temporal visual data analysis is now part of a familiar application, offers new dimensions for understanding climate data.
  - Much greater ability to perform and share comparative climate analysis





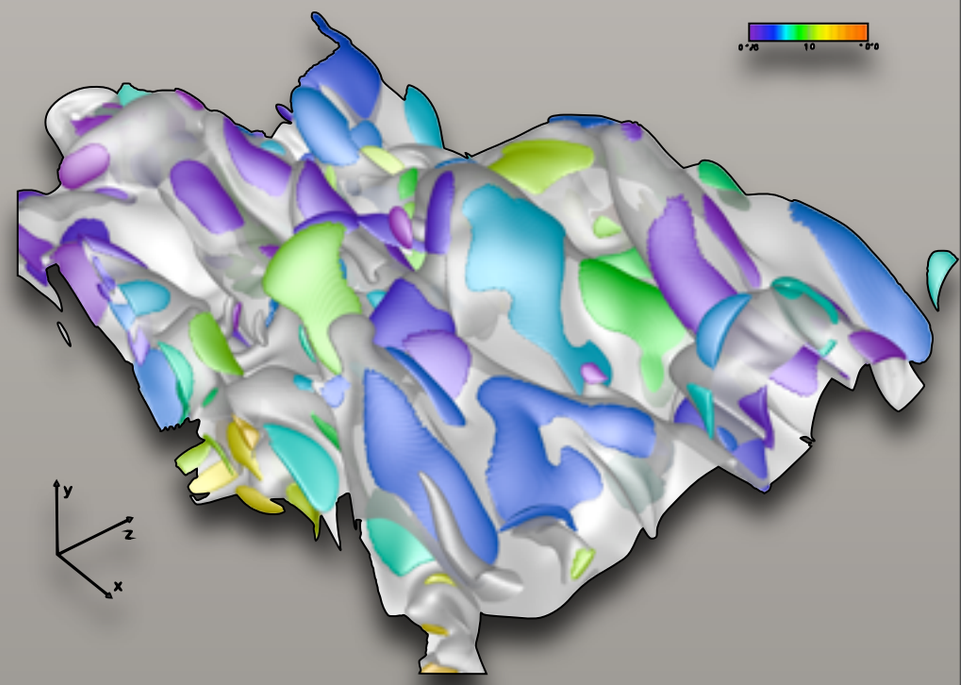
Climate, Part 2

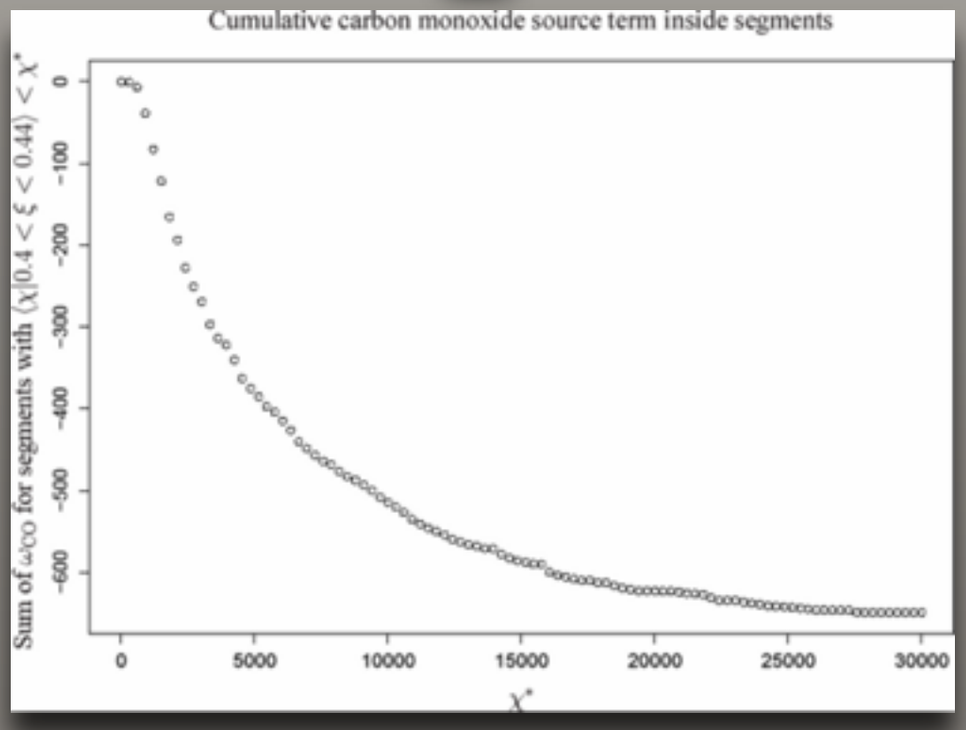
- PI: Dave Randall (CSU). SciDAC Application: Role of Clouds in Global Climate
- Accomplishments
  - Debug and optimize parallel I/O to meet performance objectives.
  - New visualization infrastructure for icosahedral grid.
- Science Impact
  - Enable effective use of INCITE allocation at NERSC
  - Critical software infrastructure to enable visualization and analysis of ensemble runs of new global cloud models.
- Other Collaborators:
  - NERSC Center staff
  - Karen Schuchardt (PNNL)



Combustion, Part 2

- PI: Jacqueline Chen (SNL-CA), INCITE awardee
- Accomplishment(s)
  - Algorithms for feature segmentation, tracking, and analysis
  - Co-authors on multiple papers
- Science Impact(s)
  - New capability: first-ever ability to see relationship between simulation parameters (e.g., level of turbulence) and scalar dissipation rate

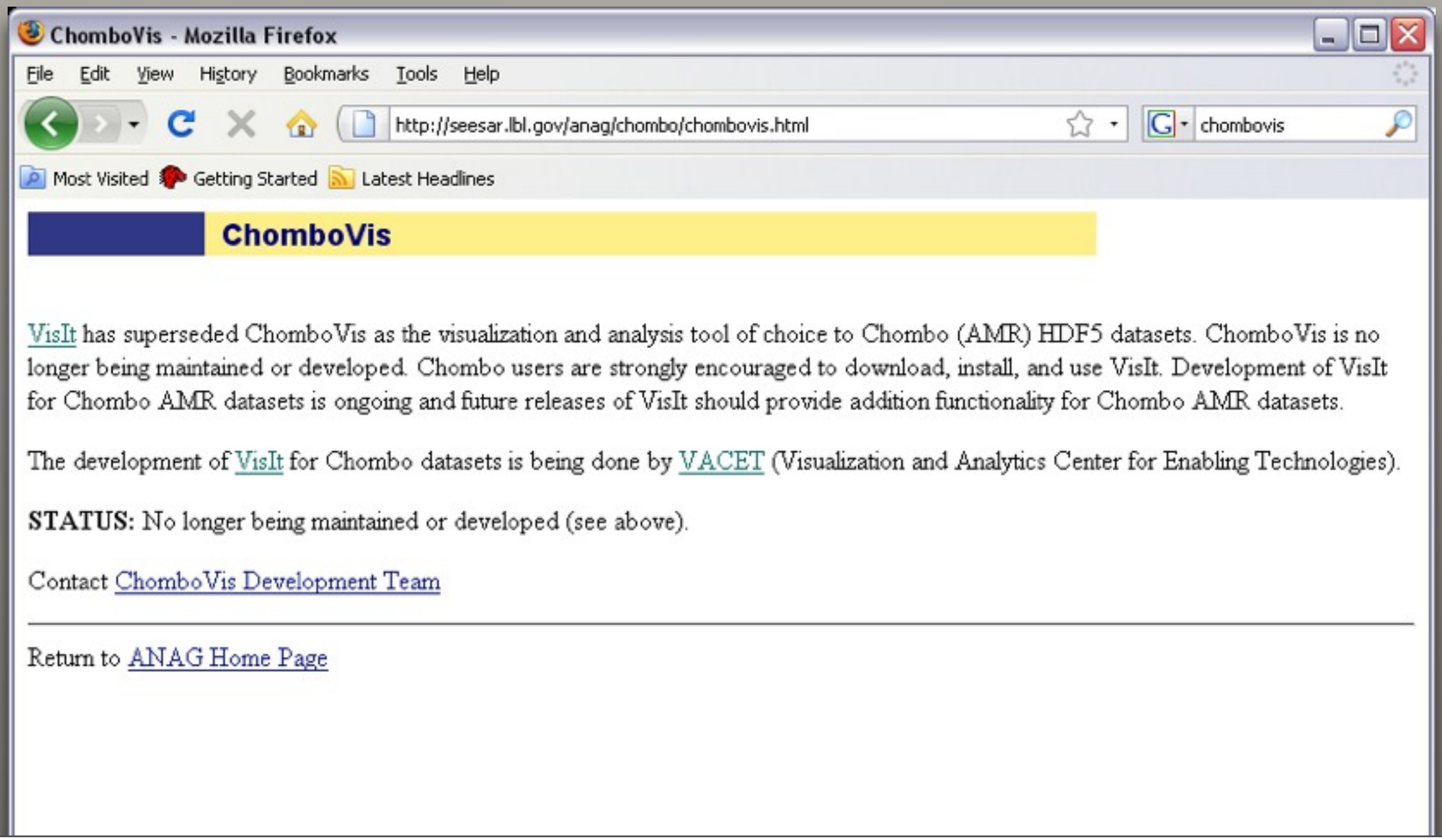




Stakeholders voting with their feet

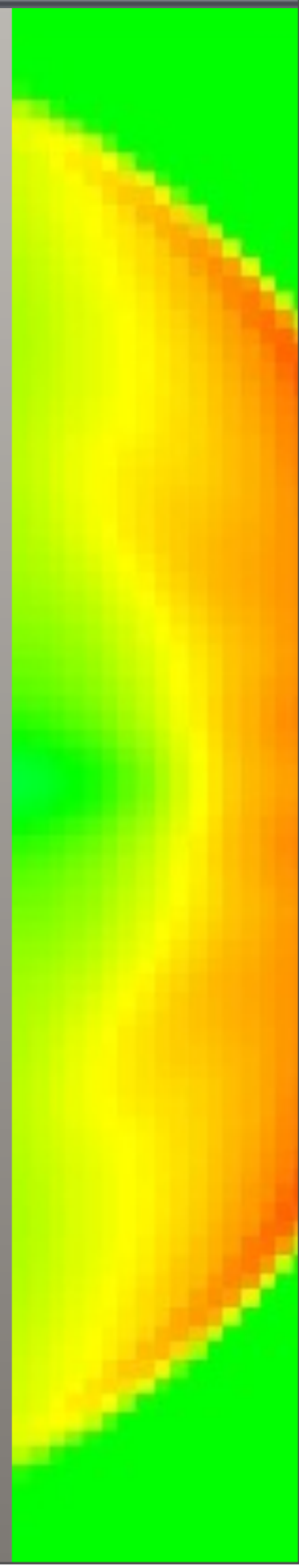
Stakeholders Vote with their Feet

- ADPEC adopts VisIt for production-quality AMR visualization



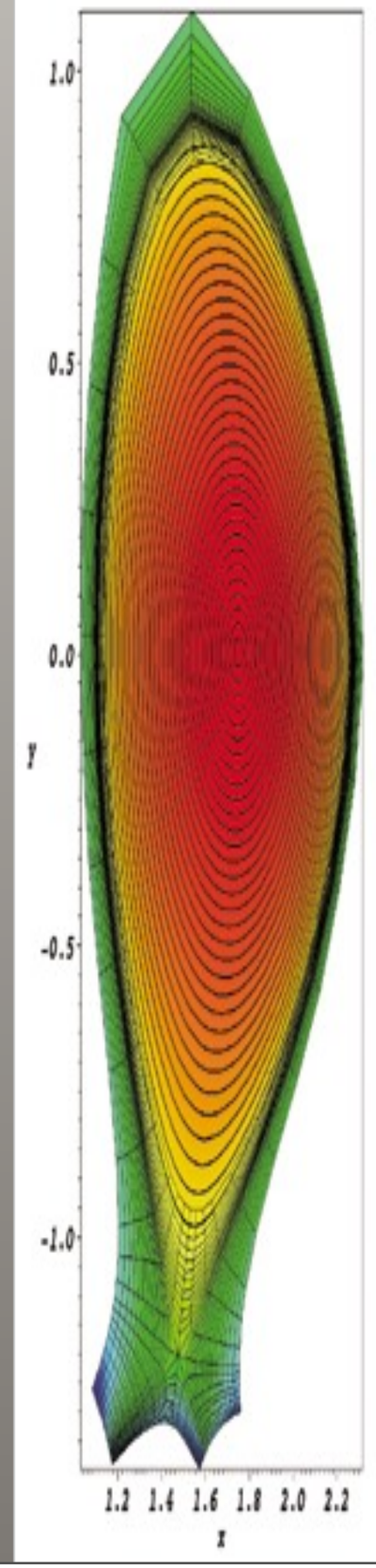
Stakeholders Vote with their Feet

- John Bell (LBNL) at the Spring 2008 Community Astrophysics Consortium Meeting:
  - VisIt adopted by the CAC for use across the project
    - Bell's is the primary SN modeling code
    - Spectral analysis groups also moving to VisIt.



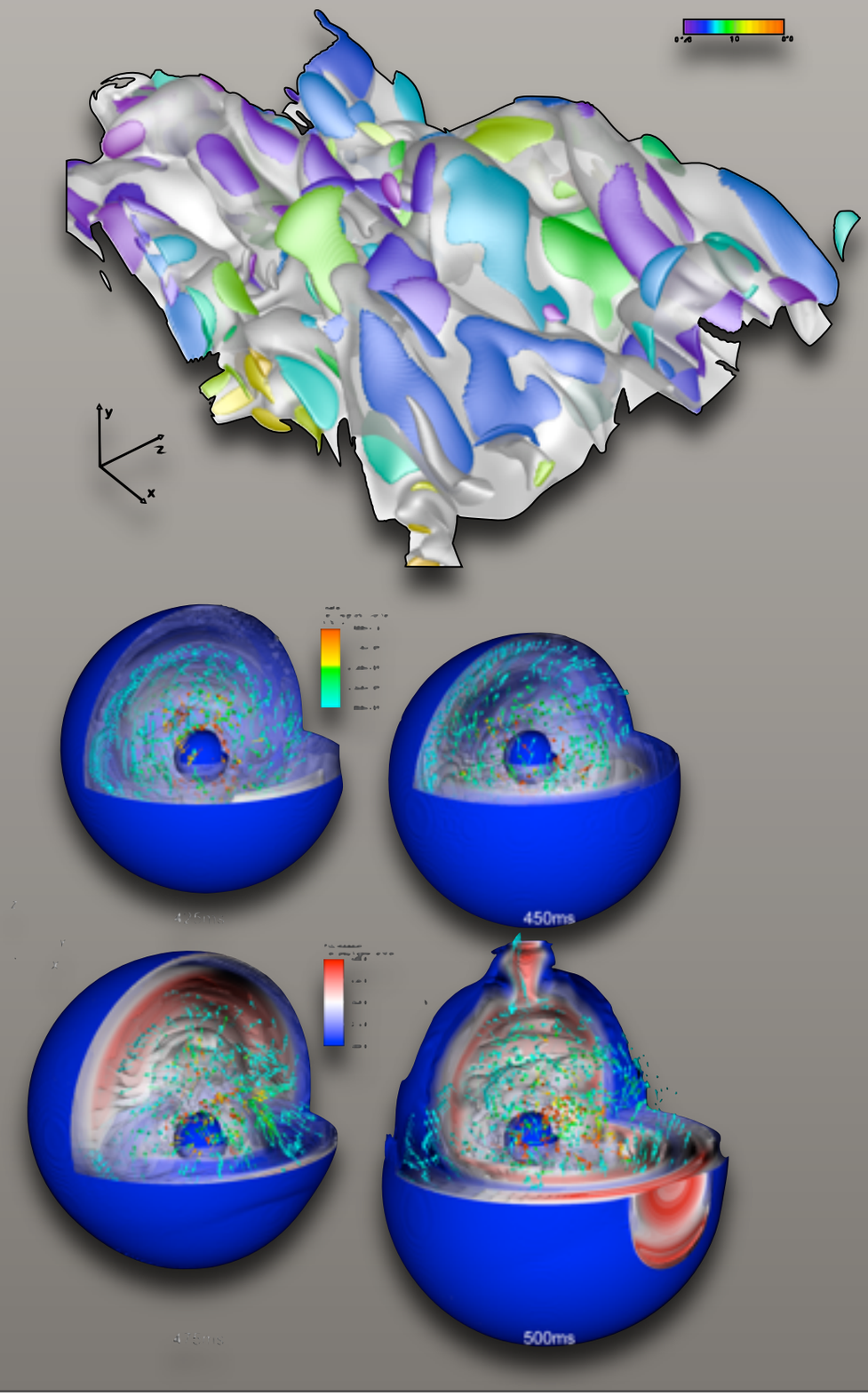
Stakeholders Vote with their Feet

- John Cary (Tech-X)
  - Making concerted effort to migrate FACETS and numerous other Tech-X efforts to VisIt.
  - Generated an animation using VisIt that won an award at SciDAC 2008.
  - Contributing to VisIt in the form of file loaders (VORPAL loader).
  - Using VisIt-generated visuals in day-to-day science activities and for special events (e.g., upcoming review).



Stakeholders Vote with their Feet

- Jacqueline Chen (SNL-CA)
  - In her SciDAC 2008 presentation: “For the first time, I can see …”
  - She recruited two former VACET members to work exclusively on continuing this project.
- Bronson Messer (ORNL)
  (Working with Tony Mezzacappa)
  - Entire team using VACET technology for all large data analysis and visualization
  - All visuals in SciDAC 2008 presentation and poster done using VACET technology.



Science Impact Summary

- New science results from multidisciplinary teams working on a challenging data understanding problem.
  - Such collaborative efforts require a substantial investment of time – thanks to SciDAC program!

- Work spans:
  - Data I/O, data models, veneer data I/O APIs
    - Encapsulating complexity, scalability.
  - Visualization algorithm architectures
  - Computational topology
  - Scalability, tuning, debugging
  - Institutional support (ORNL/LCF, ANL/LCF, LBL/NERSC)
  - Continual software support for analysis and visualization